The herpetofauna of Melbourne: using past and present distributions to assess impacts of urbanisation

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Abstract
Urbanisation is currently impacting frog and reptile species worldwide through the loss of native habitats. Broad changes in the distribution and abundance of frog and reptile species in the Melbourne area were assessed from 1850–2006 using historical sources and wildlife databases. A total of six species of frogs (out of 16 species) and 26 species of reptiles (out of 39 species) were recorded in fewer Local Government Areas from 1990 to 2006 than from 1850 to 1989. These results suggest that there have been substantial declines in the distribution and abundance of species, particularly reptiles. Several species are on the edge of their natural distribution in the Melbourne area, which may confound assessments of the impact of urbanisation. Preserving habitat remnants on the urban fringe is likely to be the most effective means of conserving extant species. Establishing long-term monitoring programs of frogs and reptiles in the Melbourne area is recommended. (*The Victorian Naturalist* **128** (5) 2011, 162–173)

Keywords: conservation; ecology; frog; reptile; wildlife database

Introduction

Over one-third of the world's known amphibian species are currently threatened by urbanisation (Hamer and McDonnell 2008) and, although estimates of the current number of reptile species threatened by urban development are lacking, reptiles appear to be in greater danger of extinction worldwide than amphibians (Gibbons *et al.* 2000). Urbanisation results in significant changes to the habitats of many animals including the loss, isolation and fragmentation of native habitat, altered disturbance regimes and invasions by non-indigenous predators (McDonnell and Holland 2008). Natural habitats are replaced with urban infrastructure such as houses, buildings, roads and other impermeable surfaces (McDonnell and Pickett 1993). Urbanisation is thus a major cause of the local extinction of native species (Czech *et al.* 2000).

The city of Melbourne, Victoria, was first settled by European people in 1835 and has grown from around 10 000 human inhabitants in 1840 to approximately 3.5 million residents today, spread over approximately 4000 km^2 (Harvey 1982; State of Victoria 2002). It is predicted that by 2051 the population of Melbourne will be 5 million, with recent projections anticipating the need for an additional 620 000 dwellings by 2030 (State of Victoria 2002). Most of this new growth will be in the form of urban sprawl (McDonnell and Holland 2008).

The impacts of urbanisation on Australian frog and reptile species are profound. For example, Hamer and McDonnell (2010) demonstrated clear differences in the ability of herpetofauna to persist in the Melbourne area after 171 years of urbanisation, with reptiles appearing less able to cope with the heavily urbanised matrix of the inner suburbs. In the Sydney metropolitan area, Shea (2010) found that most reptile species had declined or disappeared over the past 140 years in suburban environments and adjacent small bushland fragments. Both studies used species' records in herpetological databases to determine which species persisted in certain areas under the influence of urbanisation. In this study, records from historical sources and two wildlife databases were used to assess changes in the distribution and abundance of frog and reptile species in the Melbourne area. The aims of this study were to: (1) gauge trends in the abundance of species from 1900 to 1995; and (2) determine broad temporal and spatial trends in the distribution of species from 1850 to 2006.

Methods

Historical accounts of Melbourne's herpetofauna

Historical information on the distribution and abundance of frogs and reptiles in the Melbourne area was obtained using several articles published in *The Victorian Naturalist* (e.g. Littlejohn 1963; Rawlinson 1965), and the *Handbook of Melbourne* (Spencer 1900). Some changes to species' taxonomy have occurred since these early publications, which can potentially cause confusion, so only scientific names from Cogger (2000) have been used. In some cases species' identifications had to be inferred from Spencer (1900) where species' names did not match those in Cogger (2000). Information on the distribution and status of herpetofauna in Melbourne was also gleaned from Larwill (1995). Species' misidentifications, changes in taxonomy and recent introductions of species are all likely to affect the reliability of inferring trends by using historical sources of information.

Assessment of wildlife databases

Records of frogs and reptiles in the Melbourne area were obtained from the Atlas of Victorian Wildlife (AVW), which is managed by the Victorian Department of Sustainability and Environment (DSE), for the time period from 1850 to 2006, and the frog records were supplemented with data from the Melbourne Water Frog Census from 2001 to 2006. Records in the Frog Census are intended to be incorporated into the AVW (S Leech, DSE, pers. comm. 2008), but were not included at the time the records were extracted in May 2008. The year 2006 was used as the final year of observation for records extracted from the AVW because of an incomplete dataset in 2007 (only one frog and one reptile sighting were reported for 2007 at the time of data extraction).

Data were filtered to ensure a minimum standard of quality for all records, using the criteria established for assessing herpetological database records in Hamer and McDonnell (2010). For example, duplicate records, records of species made only to genus level and records where the date of observation was missing were deleted, and subspecies were grouped as a single species. Multiple sightings of a species at a single site on the same day were recorded as a single sighting. The number of frog and reptile records was summed for each year to illustrate temporal trends in reporting rates over the period 1850–2006. Broad spatial trends in the distribution of species were assessed by comparing the number of Local Government Areas (LGAs) where each species was recorded in the years before 1990 (i.e. 1850–1989) to the number of LGAs post-1990 (i.e. 1990–2006). The LGAs assessed corresponded to the 31 LGAs included in the study area of Hamer and McDonnell (2010), extending to a radius of approximately 40–60 km from the centre of Melbourne (Leary and McDonnell 2001). A Pearson product-moment correlation was conducted between the number of records of each species and the number of LGAs where each was recorded.

Results

Historical assessment of Melbourne's herpetofauna

Comments on the relative abundance of frog and reptile species in the Melbourne area included in publications during the 20th century revealed that there was an obvious decline in the Growling Grass Frog *Litoria raniformis*, Striped Legless Lizard *Delma impar* and White's Skink *Egernia whitii*, with these species being reported as 'common' in 1900 and 'uncommon' or 'rare' in the 1990s (Table 1). A total of five frog species that were reported as 'common' in 1900 were also reported as 'common' or 'abundant' in the 1990s. Two species of frogs and six reptile species were reported as being 'present' in 1900 and 'rare' in the 1990s. The presence of three species of frogs was reported in the 1990s but not in the 1960s. There were no accounts of the distribution and abundance of lizard and turtle species in the 1960s. One species of snake was reported as being 'common' in the 1960s but 'uncommon' in the 1990s (Lowland Copperhead *Austrelaps superbus*). Only two snake species were reported as being 'abundant' or 'common' in both the 1960s and 1990s (Tiger Snake *Notechis scutatus* and Little Whip Snake *Suta flagellum*). Seven species of frogs and 17 reptile species were reported in the 1990s to be range-restricted in the Melbourne area.

Table 1. Changes in relative abundance of frog and reptile species reported throughout the 20th century in the Melbourne area, including 1900 (Spencer 1900), the 1960s (Littlejohn 1963; Rawlinson 1965; Martin *et al.* 1966) and the 1990s (Larwill 1995). Observations by Larwill (1995) were based on AVW records collated in April 1994. A dash indicates that a species was not mentioned in publications for that time period. *noted by Larwill (1995) to have a restricted distribution in the Melbourne area. 'present' = species was reported but not its abundance. Trend in abundance refers to whether a species declined over a given time period; NA = insufficient information to infer a trend.

Scientific Name	Common Name	1900	1960s	1990s	Trend in abundance
FROGS					
**Crinia parinsignifera*	Plains Froglet	–	–	'locally common'	NA
Crinia signifera	Common Froglet	'common'	'very common'	'abundant'	no change
**Geocrinia victoriana*	Victorian Smooth Froglet	'common'	present	'locally common'	no change
Limnodynastes dumerilii	Southern Bullfrog	'common'	present	'common'	no change
Limnodynastes peronii	Striped Marsh Frog	–	present	'uncommon'	NA
Limnodynastes tasmaniensis	Spotted Marsh Frog	'common'	present	'abundant'	no change
Litoria ewingii	Southern Brown Tree Frog	present	'common'	'common'	no change
**Litoria lesueuri*	Lesueur's Frog	present	present	'rare'	NA
**Litoria paraewingii*	Plains Brown Tree Frog	–	–	'rare'	NA
Litoria peronii	Peron's Tree Frog	present	–	'rare'	NA
Litoria raniformis	Growling Grass Frog	'common'	'common'	'uncommon'	decline
Litoria verreauxii verreauxii	Whistling Tree Frog	–	'restricted'	'locally common'	no change
Neobatrachus sudelli	Common Spadefoot Toad	'not infrequently met with'	'seldom seen'	'uncommon'	no change
**Pseudophryne bibronii*	Brown Toadlet	–	present	'common'	NA
**Pseudophryne semimarmorata*	Southern Toadlet	'common'	present	'common'	no change
REPTILES					
Amphibolurus muricatus	Tree Dragon	'common'	–	'locally common'	no change
Physignathus lesueurii howitti	Gippsland Water Dragon	–	–	present	NA
**Pogona barbata*	Bearded Dragon	present	–	'rare'	NA
**Tympanocryptis diemensis*	Mountain Dragon	–	–	'rare'	NA
**Tympanocryptis pinguicolla*	Grassland Earless Dragon	–	–	'regionally rare'	NA
**Christinus marmoratus*	Marbled Gecko	present	–	'rare'	NA
Delma impar	Striped Legless Lizard	'common'	–	'rare'	decline
**Pygopus lepidopodus*	Common Scaly-foot	present	–	'extremely rare'	NA
**Varanus varius*	Tree Goanna	present	–	'rare'	NA
Bassiana duperreyi	Eastern Three-lined Skink	–	–	'uncommon'	NA
**Ctenotus robustus*	Large Striped Skink	–	–	'locally common'	NA
**Egernia coventryi*	Swamp Skink	–	–	'rare'	NA
**Egernia cunninghami*	Cunningham's Skink	–	–	'uncommon'	NA
**Egernia saxatilis intermedia*	Black Rock Skink	–	–	'uncommon'	NA
**Egernia whitii*	White's Skink	'very common'	–	'uncommon'	decline

Table 1. Continued.

Scientific Name	Common Name	1900	1960s	1990s	Trend in abundance
Eulamprus tympanum tympanum	Southern Water Skink	–	–	'uncommon'	NA
Lampropholis delicata	Delicate Skink	–	–	'uncommon'	NA
Lampropholis guichenoti	Garden Skink	present	–	'common'	NA
Lerista bougainvillii	Bougainville's Skink	–	–	'uncommon'	NA
Nannoscincus maccoyi	McCoy's Skink	present	–	'locally common'	NA
Niveoscincus coventryi	Coventry's Skink	–	–	'rare'	NA
**Niveoscincus metallicus*	Metallic Skink	present	–	'rare'	NA
Pseudemoia entrecasteauxii	Southern Grass Skink	–	–	'uncommon to rare'	NA
**Pseudemoia pagenstecheri*	Tussock Skink	–	–	'locally common'	NA
Pseudemoia rawlinsoni	Glossy Grass Skink	–	–	'rare'	NA
**Pseudemoia spenceri*	Spencer's Skink	–	–	'rare'	NA
**Saproscincus mustelinus*	Weasel Skink	–	–	'common'	NA
Tiliqua nigrolutea	Blotched Blue-tongued Lizard	–	–	'uncommon'	NA
Tiliqua rugosa	Stumpy-tailed Lizard	present	–	'rarely seen'	NA
Tiliqua scincoides	Common Blue-tongued Lizard	present	–	'common'	NA
Austrelaps superbus	Lowland Copperhead	–	'common'	'uncommon'	decline
Drysdalia coronoides	White-lipped Snake	–	present	'uncommon'	NA
Notechis scutatus	Tiger Snake	–	'abundant'	'common'	no change
Pseudechis porphyriacus	Red-bellied Black Snake	–	'not very common'	'regionally rare'	no change
Pseudonaja textilis	Eastern Brown Snake	–	'not abundant'	'uncommon'	no change
**Rhinoplocephalus nigrescens*	Eastern Small-eyed Snake	–	'not abundant'	'uncommon'	no change
**Suta flagellum*	Little Whip Snake	–	'abundant'	'locally common'	no change
Chelodina longicollis	Common Long-necked Turtle	–	–	'uncommon'	NA
Emydura macquarii	Murray River Turtle	–	–	'uncommon'	NA
Macrochelodina expansa	Broad-shelled Turtle	–	–	present	NA

Number of species and records in wildlife databases

There were a total of 4763 records of 16 species of frogs, and 3752 records of 39 species of reptiles recorded in the wildlife databases examined for the Melbourne area, 1850–2006 (Table 2). There were two frog species and seven reptile species recorded in the databases that were not present in the Melbourne area at the time of European settlement, hence they are considered to be non-indigenous. The number of records of each frog species ranged from two (Plains Froglet *Crinia parinsignifera*) to 1275 (Common Froglet *Crinia signifera*), while the number of reptile records ranged from two (Spencer's Skink *Pseudemoia spenceri* and Broad-shelled Turtle *Macrochelodina expansa*) to 513 (Garden Skink *Lampropholis guichenoti*). The frog species recorded in the highest number of LGAs was the Common Froglet (n = 31), whereas the Plains Froglet was recorded in only one LGA. The Garden Skink was the reptile species recorded in the highest number of LGAs (n = 29), whereas the Bearded Dragon *Pogona barbata*, Common Scaly-foot *Pygopus lepidopodus*, Spencer's Skink and Broad-shelled Turtle were all recorded in only two LGAs. There was a strong correlation between the number of records of each species and the number of LGAs where each was recorded (frogs: $r = 0.81$, $p < 0.001$; reptiles: $r = 0.80$, $p < 0.001$). There were a total of three frogs and five reptile species recorded in the Melbourne area that are considered to be at risk of extinction (endangered or vulnerable; DSE 2007).

The reporting rates of frog and reptile species, as inferred from the date of each record, showed high variation over time with a distinct peak in the number of records for each taxon in the period of ca. 1985–1995 (Fig. 1). There was a second peak in the number of records of frog and reptile species in 2004 (n = 325) and 2001 (n = 175), respectively. The number of records of frog species per year was < 7 in the years prior to 1960, increasing to a maximum of 560 records in 1988, with 65.5% of records being from 1990–2006. The number of records of reptile species per year was also low in the period 1850–1959, but there were more records of reptile species than frogs made during this period (178 cf. 51 records, respectively). A maximum of 481 records of reptile species was made in 1988, with 50.8% of records being from 1990–2006.

Changes in the distribution of frog and reptile species since 1850

A total of six species of frogs (43% of 14 indigenous species) were recorded in fewer LGAs in 1990–2006 than in 1850–1989 (Fig. 2). The Southern Toadlet *Pseudophryne semimarmorata* was recorded in eight fewer LGAs in the 16 years after 1990 than before this period. Eight species of frogs were recorded in more LGAs from 1990 onwards, with the Striped Marsh Frog *Limnodynastes peronii* being recorded in an additional 12 LGAs than prior to 1990. Two species showed no change in the number of LGAs they were recorded in before and after 1990 (Plains Froglet and Haswell's Froglet *Paracrinia haswelli*).

There were 26 species of reptiles (81% of 32 indigenous species) recorded in fewer LGAs from 1990–2006 than during the time period 1850–1989 (Fig. 2). The Eastern Small-eyed Snake *Rhinoplocephalus nigrescens* was recorded in 10 fewer LGAs in the period 1990–2006 than in the 140 years prior to this. Seven species of reptiles were recorded in more LGAs from 1990 onwards, with the Tussock Skink *Pseudemoia pagenstecheri* being recorded in five more LGAs than prior to 1990. Three species showed no change in the number of LGAs they were recorded in before and after 1990 (Southern Water Skink *Eulamprus tympanum tympanum*, Southern Grass Skink *Pseudemoia entrecasteauxii* and the Common Scaly-foot).

Discussion

Using records of frog and reptile species contained in two wildlife databases, substantial differences in the distribution of species from 1850–2006 were demonstrated. Reptile species appear to have declined over widespread areas of Melbourne, and declined in more LGAs than frog species since 1990. This result mirrors that of Hamer and McDonnell (2010) who analysed the same sighting records from the same time period used in this study and found that only 56% of the 39 reptile species recorded were estimated to have ≥ 95% probability of being present in the year 2006, compared with 81% of the 16 frog species recorded. Together, these

Table 2. The frog and reptile species recorded in 31 Local Government Areas in Melbourne, 1850–2006. Records were extracted from the Atlas of Victorian Wildlife and Melbourne Water Frog Census. Scientific names follow Cogger (2000). Conservation status refers to listings under the *Advisory List of Threatened Vertebrate Fauna in Victoria* (DSE 2007): CR = critically endangered; EN = endangered; VU = vulnerable; NT = near threatened; DD = data deficient. First year is the earliest record of a species; last year is the most recent record of a species. LGA = Local Government Area. *non-indigenous species (see Hamer and McDonnell 2010).

Scientific Name	Common Name	Conservation Status	First Year	Last Year	No of LGAs	Total No of Records
FROGS						
Ground frogs (Myobatrachidae)						
Crinia parinsignifera	Plains Froglet	–	1988	1991	1	2
Crinia signifera	Common Froglet	–	1869	2006	31	1275
Geocrinia victoriana	Victorian Smooth Froglet	–	1958	2006	15	152
Limnodynastes dumerilii	Southern Bullfrog	–	1869	2006	30	488
Limnodynastes peronii	Striped Marsh Frog	–	1957	2006	26	214
Limnodynastes tasmaniensis	Spotted Marsh Frog	–	1868	2006	30	735
Neobatrachus sudelli	Common Spadefoot Toad	–	1869	2005	17	61
Paracrinia haswelli	Haswell's Froglet	–	1967	2005	4	12
Pseudophryne bibronii	Brown Toadlet	EN	1856	2005	13	44
Pseudophryne semimarmorata	Southern Toadlet	VU	1890	2004	16	117
Tree frogs (Hylidae)						
Litoria ewingii	Southern Brown Tree Frog	–	1864	2006	27	825
**Litoria fallax*	Eastern Dwarf Tree Frog	–	1999	2006	7	12
Litoria lesueuri	Lesueur's Frog	–	1966	1993	3	10
**Litoria peronii*	Peron's Tree Frog	–	1988	2006	12	56
Litoria raniformis	Growling Grass Frog	EN	1882	2006	26	436
Litoria verreauxii verreauxii	Whistling Tree Frog	–	1961	2006	20	324
Total: 16 species					31	4763
REPTILES						
Dragons (Agamidae)						
Amphibolurus muricatus	Tree Dragon	–	1883	2006	16	122
**Physignathus lesueurii howitti*	Gippsland Water Dragon	–	1989	2001	3	7
**Pogona barbata*	Bearded Dragon	DD	1986	1990	2	3
Tympanocryptis pinguicolla	Grassland Earless Dragon	CR	1872	1990	5	6
Geckos (Gekkonidae)						
**Christinus marmoratus*	Marbled Gecko	–	1903	2005	21	70
Legless lizards (Pygopodidae)						
Delma impar	Striped Legless Lizard	EN	1875	2005	9	160
Pygopus lepidopodus	Common Scaly-foot	–	1933	2000	2	9
Monitors (Varanidae)						
Varanus varius	Tree Goanna	VU	1932	2005	7	19
Skinks (Scincidae)						
Bassiana duperreyi	Eastern Three-lined Skink	–	1890	2004	21	132
Ctenotus robustus	Large Striped Skink	–	1876	2005	11	82
Egernia coventryi	Swamp Skink	VU	1971	2003	7	53
Egernia cunninghami	Cunningham's Skink	–	1884	2006	12	71
Egernia saxatilis intermedia	Black Rock Skink	–	1888	1999	6	15
Egernia whitii	White's Skink	–	1863	2003	21	55
Eulamprus tympanum tympanum	Southern Water Skink	–	1968	2005	17	104
Lampropholis delicata	Delicate Skink	–	1963	2006	15	158
Lampropholis guichenoti	Garden Skink	–	1871	2006	29	513
Lerista bougainvillii	Bougainville's Skink	–	1885	2002	17	101
Nannoscincus maccoyi	McCoy's Skink	–	1901	2005	8	79
Niveoscincus coventryi	Coventry's Skink	–	1915	2005	3	12

Table 2. Continued.

Scientific Name	Common Name	Conservation Status	First Year	Last Year	No of LGAs	Total No of Records
Niveoscincus metallicus	Metallic Skink	–	1934	2003	5	28
Pseudemoia entrecasteauxii	Southern Grass Skink	–	1977	2005	3	32
Pseudemoia pagenstecheri	Tussock Skink	–	1968	2005	9	24
Pseudemoia rawlinsoni	Glossy Grass Skink	NT	1972	2003	7	14
Pseudemoia spenceri	Spencer's Skink	–	1885	1979	2	2
Saproscincus mustelinus	Weasel Skink	–	1869	2006	22	210
Tiliqua nigrolutea	Blotched Blue-tongued Lizard	–	1877	2005	18	152
**Tiliqua rugosa*	Stumpy-tailed Lizard	–	1980	1991	6	7
Tiliqua scincoides	Common Blue-tongued Lizard	–	1911	2006	25	352
Snakes (Elapidae)						
Austrelaps superbus	Lowland Copperhead	–	1866	2006	22	244
Drysdalia coronoides	White-lipped Snake	–	1877	2003	17	93
Notechis scutatus	Tiger Snake	–	1860	2006	25	340
Pseudechis porphyriacus	Red-bellied Black Snake	–	1986	2005	13	28
Pseudonaja textilis	Eastern Brown Snake	–	1868	2006	20	164
Rhinoplocephalus nigrescens	Eastern Small-eyed Snake	–	1908	2006	13	49
Suta flagellum	Little Whip Snake	–	1864	2006	14	143
Turtles (Chelidae)						
**Chelodina longicollis*	Common Long-necked Turtle	–	1970	2006	24	94
**Emydura macquarii*	Murray River Turtle	DD	1990	2006	3	3
**Macrochelodina expansa*	Broad-shelled Turtle	EN	1991	1992	2	2
Total: 39 species						3752

results imply that reptiles have been negatively affected by urbanisation of the Melbourne area to a much greater extent than frogs. These declines in the herpetofauna can be attributed primarily to habitat loss, habitat fragmentation and isolation, and reductions in the complexity of terrestrial habitat structure (Hamer and McDonnell 2010).

Although dramatic global declines in the distribution and abundance of reptile species in the late 20th century were documented (Gibbons *et al.* 2000), they did not attract the same level of interest from scientists as did global amphibian declines (see Collins and Storfer 2003). It has been shown by the author that a wide suite of reptile taxa (dragons, geckos, legless lizards, monitors, skinks and snakes) have undergone serious reductions in their distribution in the Melbourne area. While many of these species' declines are likely to reflect actual disappearances from areas, some relatively common species that persist in inner suburbs appeared to have experienced reductions (e.g. Garden Skink and Common Blue-tongued Lizard *Tiliqua scincoides*). The data examined in the AVW contain biases that need to be considered before accepting apparent trends in the distribution of species (van der Ree 2004), and common species may be less frequently reported to the AVW in favour of more interesting sightings such as those of threatened species that may be cryptic or occur at very low densities and therefore be infrequently observed. For example, many of the records of the Striped Legless Lizard originated from individuals encountered during physical destruction of their grassland habitat (Larwill 1995), and the apparent decline in the distribution of the Eastern Small-eyed Snake may be related to its cryptic habits. Despite these declines, some reptile species have expanded their distribution, although these include largely non-indigenous species (e.g. turtles) or species that have attracted increased survey effort because of their conservation status (e.g. Swamp Skink *Egernia coventryi*; Clemann 2000). The Red-bellied Black Snake *Pseudechis porphyriacus* has also been found

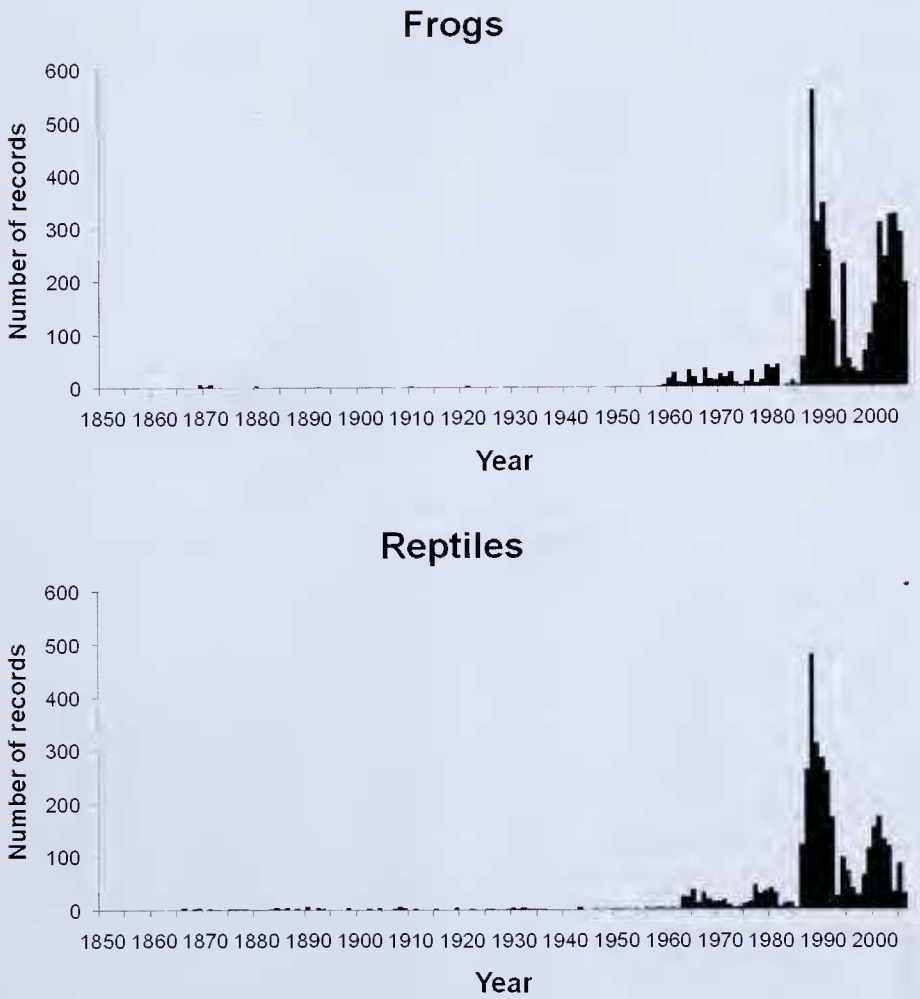

Fig. 1. The number of yearly records of frog and reptile species in 31 Local Government Areas in Melbourne, 1850–2006, obtained from two wildlife databases (Atlas of Victorian Wildlife and Melbourne Water Frog Census).

in more LGAs since 1990, although it has been suggested that some individuals recorded in the AVW are actually the morphologically similar Lowland Copperhead (Hoser 2009).

Declines in frog species in the Melbourne area are apparent for species that have specialised breeding requirements, such as the terrestrial egg-laying species (Southern Toadlet, Brown Toadlet *Pseudophryne bibronii* and Victorian Smooth Froglet *Geocrinia victoriana*). These 'urban-sensitive species' are vulnerable to the key threatening processes of urbanisation, and are likely to persist only in outer suburbs or where there is adequate habitat available (Hamer and McDonnell 2008, 2010). Six species of frogs were recorded in more LGAs after 1990 than in the period 1850–1989. While several of these species are known to be 'urban adapters' (e.g. Striped Marsh Frog and Southern Brown Tree Frog *Litoria ewingii*; Hamer and McDonnell 2010), it is likely that increased survey effort devoted to frogs because of the Frog Census has

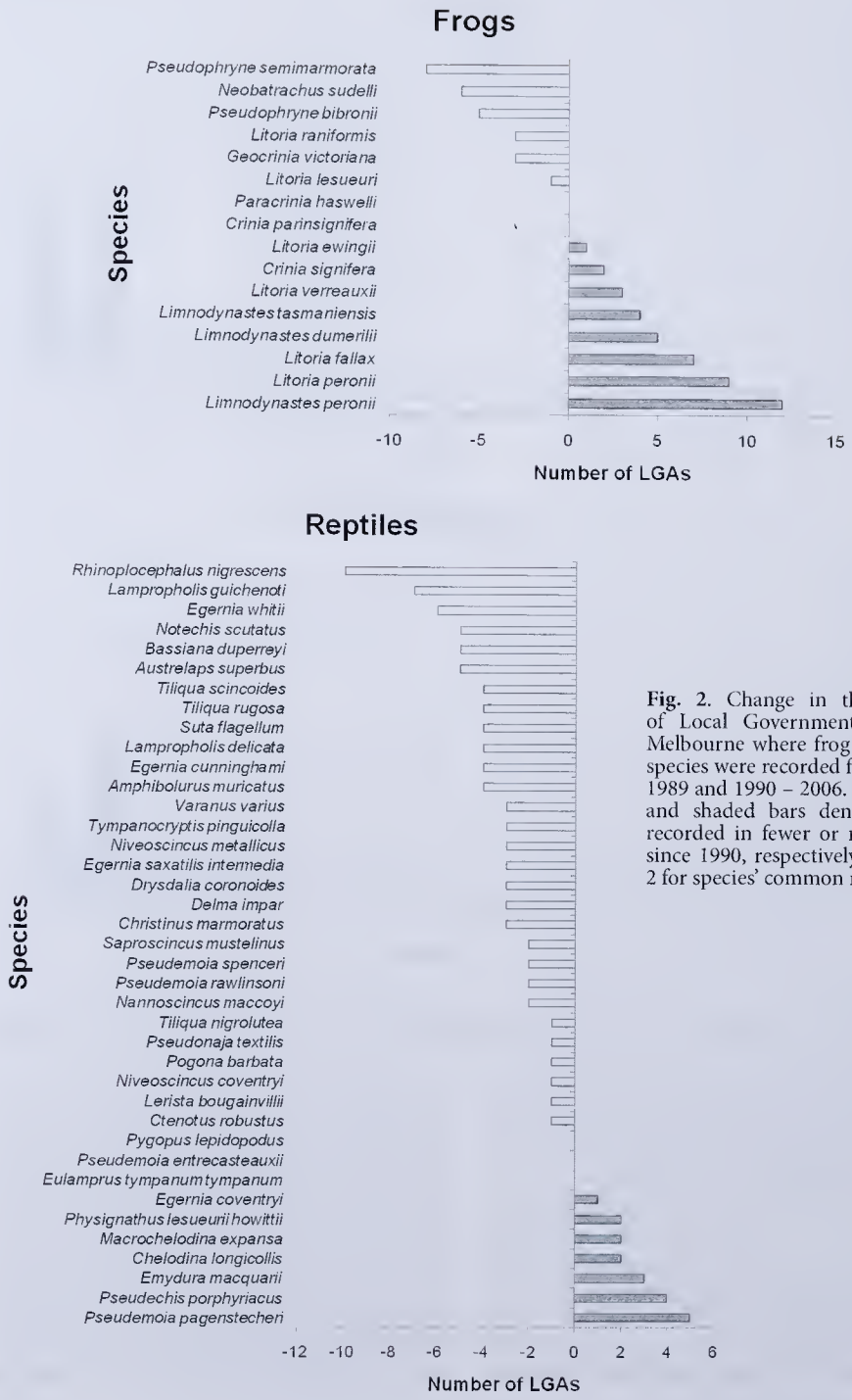

Fig. 2. Change in the number of Local Government Areas in Melbourne where frog and reptile species were recorded from 1850 – 1989 and 1990 – 2006. Empty bars and shaded bars denote species recorded in fewer or more LGAs since 1990, respectively. See Table 2 for species' common names.

increased the reporting rates of many species since 2001. The non-indigenous Eastern Dwarf Tree Frog *Litoria fallax* may be currently expanding its distribution in the Melbourne area via transportation in horticultural products (e.g. boxes of fresh fruit), although this is of concern as individuals could act as vectors of amphibian diseases (Gillespie and Clemann 2000).

Reconstructing the past using historical accounts refines our ability to assess the conservation status of species. Examination of accounts of the relative abundance of species over the 20th century indicated that the Growling Grass Frog declined in the Melbourne area between the 1960s and 1990s, which is the period of declines observed in many amphibian populations worldwide (Houlahan *et al.* 2000). It is evident that urbanisation was the major driver of the declines of frog and reptile species in the Melbourne area (Hamer and McDonnell 2010), with Littlejohn (1963: p. 296) being the first to attribute the decline of frog populations within 25 miles (40 km) of the Melbourne General Post Office to urbanisation, commenting that 'most of them probably once occurred across the region of maximum urbanization, but, except in a few pockets (e.g. parks and golf courses), they have yielded to the drastic environmental change'. Consistent with the spatial expansion of urban areas around the world, the continuing urbanisation of Melbourne will increase residential development and other associated infrastructure in undeveloped areas within the outer suburbs (State of Victoria 2002). The conservation outlook for many of the species in the Melbourne area is bleak, given the continued urban development and expansion earmarked for the urban-fringe areas, and the conservation status of both listed and unlisted species needs to be urgently reassessed and revised. Preventing the local extinction of species on the urban fringe will require the preservation of large, well-connected remnant patches with a diversity of habitat types.

Many of the species Larwill (1995) considered as rare and range-restricted, and many species Hamer and McDonnell (2010) estimated to have a low probability of persistence, are either on the edge of their natural distribution or have been introduced into Melbourne since European settlement. Species that are on the periphery of their natural range in the region limit our ability to rigorously assess the impact of urbanisation as they were unlikely to have historically (pre-European settlement) occurred in the inner Melbourne area, and any contractions in their range may not necessarily be due to human disturbance and modification of their natural habitat. Wildlife populations on the edge of their natural range, while still persisting, tend to be more fragmented and less abundant and therefore experience higher incidences of local extinction (Channell and Lomolino 2000), which may confound assessments of their persistence in urban and suburban areas. The Melbourne area is located within a transition of four biogeographic zones: Volcanic Plains, Central Victorian Uplands, Highlands Southern Fall and Gippsland Plain (Thackway and Cresswell 1995), with each having a set of characteristic habitats and hence specific associations of frog and reptile species within these habitats (Larwill 1995). This may account for the high diversity of reptile species recorded in the Melbourne area, which supports 25 indigenous species of lizards out of the total of 87 species recorded in Victoria.

The range of several skink species is naturally restricted in the Melbourne area, with their distributional limit being the forested ranges in the east, north-east and north-west, or the South Gippsland plains. For example, the Swamp Skink, Glossy Grass Skink *Pseudemoia rawlinsoni* and Metallic Skink *Niveoscincus metallicus* have never been recorded in inner Melbourne suburbs but are known from outer suburbs on the Gippsland Plain to the southeast. Similarly, the natural ranges of Spencer's Skink and the Black Rock Skink *Egernia saxatilis intermedia* extend into the outer Melbourne area to the northwest and east. Several species of snakes are also range-restricted in the Melbourne area (e.g. the Eastern Small-eyed Snake). The historic absence of these species towards the centre of Melbourne is probably due either to the relatively low topographic relief of inner Melbourne, which does not support the forested habitat or rocky escarpment country that these species require, or because of the transition of biogeographic zones around Melbourne, which provides

natural boundaries for species' distributions.

Range restrictions are also evident amongst the frog fauna. For example, the natural range of Lesueur's Frog *Litoria lesueuri* in the Melbourne area is limited to riparian habitats to the northwest, and historically, the species is unlikely to have been abundant in areas towards the inner city (Martin *et al.* 1966). Similarly, the natural distribution of the Plains Froglet is mainly north of the Great Dividing Range with the southern limit extending into the foothills in the outer northern suburbs (Larwill 1995). The natural distribution of Haswell's Froglet is at its western limit on the Mornington Peninsula (Hero *et al.* 1991), which may explain its absence from inner suburbs. The fact that the Plains Froglet and Haswell's Froglet are at the edge of their natural distribution in the Melbourne area may account for why there was no change in the number of LGAs that each species was recorded in before and after 1990, illustrating the difficulty in assessing trends in locally range-restricted species.

The gap in the Great Dividing Range to the north of Melbourne in the vicinity of Wallan (the 'Kilmore Gap') is a passage of lower topographic relief that potentially enables the movement of fauna between the riverine plains to the north and the northern outskirts of Melbourne. This geographical feature has likely enabled the distribution of a suite of frogs and reptiles to extend their distribution into the Melbourne area, and has probably assisted in populations of non-indigenous species becoming established. For example, Peron's Tree Frog *Litoria peronii* was first recorded from the northern suburbs of Melbourne (Whittlesea) in 1985 and is assumed to be non-indigenous. It is found mainly to the north of the Great Divide and its appearance to the south may have been assisted through the movement of frogs during the inadvertent transport of horticultural and timber products (e.g. pot plants and firewood). Another species found mainly to the north of the Great Divide is the Marbled Gecko *Christinus marmoratus*, which is not indigenous to Melbourne and has likely become established as a stowaway in timber products and rocks transported from northern Victoria.

The ability to detect apparent trends in the distribution and abundance of species in the Melbourne area may be confounded by variations in reporting rates contained within the databases examined. For example, there was a major peak in the number of records of frog and reptile species in the period ca. 1985–1995 (Fig. 1). This peak coincides with a period of detailed fauna surveys undertaken by the Arthur Rylah Institute for Environmental Research in the outer suburbs of Melbourne, and is similar to the temporal distribution of AVW records of mammals in the same area (van der Ree 2004). There was a second peak in the number of records of frog and reptile species in the early 2000s. The increased survey effort devoted to frogs because of the Frog Census no doubt contributed to this peak, as well as increased frequency of surveys that target threatened species conducted by zoological consultants to assess new residential and industrial developments throughout the Melbourne area. These surveys also record a suite of non-target fauna, and these records are required to be submitted to the AVW as a condition of wildlife research permits issued by DSE.

Given the substantial declines in frog and reptile species in the Melbourne area, and the absence of a community monitoring program for reptiles, it seems prudent to recommend implementing a long-term monitoring program for both taxa in the inner and outer suburbs in order to assess the future effects of urbanisation on herpetofauna. There was no inventory of lizard species in the 1960s, despite the papers on other herpetological taxa, making it especially difficult to gauge declines in lizards in the latter half of the 20th century. Declines in reptile species have largely escaped the attention of biologists, and reptiles are among the least studied taxonomic groups in studies on urbanisation (McDonnell and Hahs 2008). It is, therefore, advocated: (1) repeated systematic surveys at designated survey sites for frogs and reptiles along the urban-rural gradient of Melbourne over the long term (i.e. > 3 years); and (2) greater involvement by the DSE in encouraging the general public to submit records of reptiles to the AVW. These actions will be critical in assessing future impacts of urbanisation on herpetofauna that will undoubtedly result from urban expansion in the Melbourne area.

Acknowledgements

I thank Mark McDonnell, Rodney van der Ree, Julia Stammers and Amy Hahs for their assistance in this study. Scott Leech provided species' records from the AVW database, and Graham Rooney and Tania Struzina provided records from the Melbourne Water Frog Census. The Baker Foundation provided generous support for this research.

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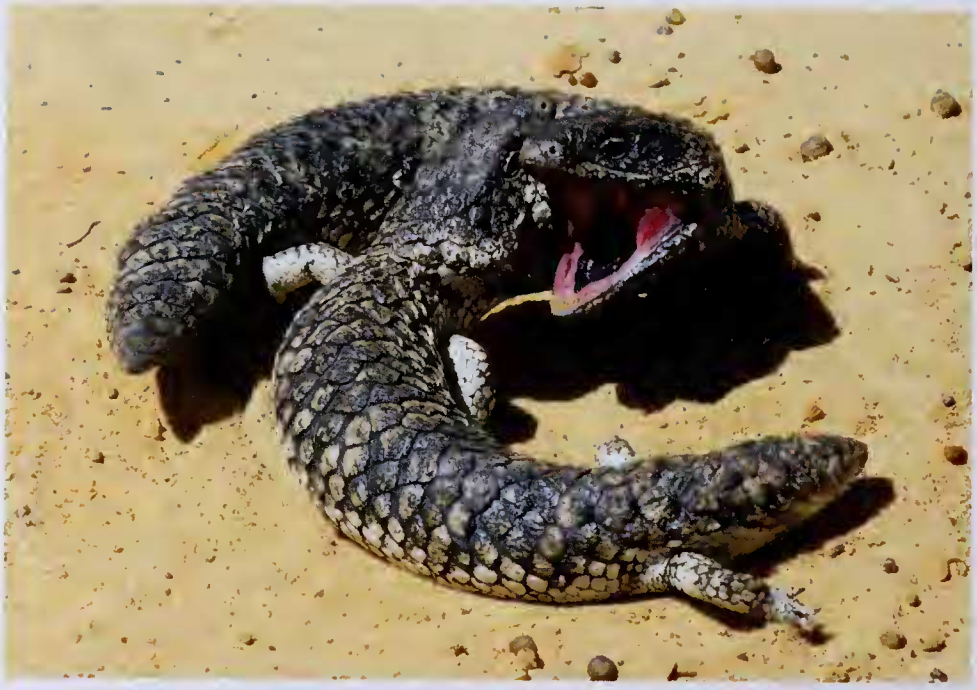
Received 3 February; accepted 11 August 2011

Striped Marsh Frog *Limnodynastes peroni*. Photo by Anne Morton.



Above: Stumpy-tailed lizards *Tiliqua rugosa*. Photo by Maria Gibson.

Below: Blotched Blue-tongued Lizard *Tiliqua nigrolutea*. Photo by Anne Morton.